EUROPEAN PATENT APPLICATION

(12)

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(54) **System and method of sensing current in high voltage transmission lines utilizing the transmission of digital information by optical fibers.**

(57) A system and a method for sensing and reproducing a measured current value on a high voltage transmission line. An input shunt means (11) senses a current to be measured. A transmitter circuit transmits a sampled current value of the current passing through the shunt means. The transmitter has converter circuits (21, 22) for reproducing a composite output digital coded signal representative of the sample current value. A light transmitting output means (28, 29) is provided for transmission of the composite output digital coded signal on an optical fiber transmission line (12) to a receiver circuit. The receiver circuit has decoding circuit means for decoding and reconstituting the coded signal to a usable form to determine the sampled current value.

EP 0 026 930 A1

System and method of sensing current in high voltage
transmission lines utilizing the transmission of digital
information by optical fibers.

5

      The present invention relates to a system and a method
for measuring current in a high voltage transmission line and
transmitting the measured values by fiber optics. Particularly,
but not exclusively, the measuring may be effected on a conti-
10 nuing basis and at high frequencies.

      Because of increasing requirements for higher voltages,
the transformers used in transmission lines are becoming larger
and larger and more expensive to fabricate and install.
Furthermore, existing test apparatus are not well isolated
15 from radio frequency interference and thus subjected to noise
and are not readily adaptable to computer or microprocessor-
type measuring apparatus which are becoming more and more
prevalent.

      There is, therefore, a need to use more advanced
20 technology in high voltage transmission systems and the present
invention is concerned with the utilization of optical fibers
to carry transmitted information from a sensor circuit located
on a high voltage line. An advantage of using such optical
fibers is that they have good voltage isolation qualities and
25 noise immunities. The present invention makes it possible to
use low voltage electronic circuits to code information obtained
by a sensing circuit and to transmit such information by optical
fiber to a receiver circuit where the information is to be used.
The use of electronic circuits of this type permits a reduction
30 in the size of the sensing circuit and also permits the use
of a shunt to sense the current and further permits the use
of a conventional transformer to feed the supplies to the sensing
circuit which is adapted at a location on the line.

      Various types of sensing circuits have been used on
35 high voltage lines to measure the current, but the majority of
such apparatus or circuits utilize modulated coded signals or
pulse width modulation.

      A feature of the present invention is to utilize a shunt

to obtain a measurement of the current and a converter to
provide the measured signal in a form for transmission on
an optical fiber transmission line to a far end receiver for
analysis of the information.

5   Another feature of the present invention is to provide
a system and a method capable of sensing and measuring current
on a high voltage transmission line and on a continuous basis
and at high frequencies.

A further feature of the present invention is to provide
10   a system and a method for sensing and measuring current in a
high voltage transmission line and providing two or more signals
representative of the measured current and converting same for
transmission on a optical fiber transmission line and wherein
the information is in a form to be utilized by computers and
15   microprocessors.

A further feature of the present invention is that an
instantaneous value can be provided when a measured signal is
required.

According to the above features, from a broad aspect,
20   the present invention provides a system for sensing and measuring
current on a high voltage transmission line. The system comprises
an input shunt element connected to the transmission line for
sensing a current flowing therethrough. A transmitter circuit
is provided for transmitting a signal representative of said
25   current passing through said shunt element. The transmitter
has converter means for producing a composite output digital
coded signal representative of the value of the measured
current. A light transmitting output means is provided for the
transmission of the coded signal on an optical fiber transmission line
30   to a receiver circuit having decoding circuit means for decoding
and reconstituting the coded signal to a usable form to determine
the value of the measured current. The shunt element has a
resistive conducting core with an internal chamber. The transmit-
ter circuit is contained within the internal chamber to shield
35   the circuitry from electric and magnetic fields produced by
the current flowing through the conducting core around the
transmitter circuit.

In a preferred embodiment the transmission line has one

or more optical fibers fed by a light emitting device which
is a light emitting diode. The transmission carries the coded
signal which is a multi-bit word separated by a predetermined
serie of known bits. The transmission may be of the serial-
5 asynchronous type or of the serial-synchronous type.

According to a further broad aspect of the present
invention, there is provided a method of sensing and measuring
current in a high voltage transmission line. A shunt element,
having a resistive conducting core is connected to the high
10 voltage transmission line. The shunt element is provided wich
an internal chamber. A transmitter circuit is located within
the internal chamber to shield its circuitry from electric
and magnetic fields produced by current flowing through the
conducting core around the transmitter circuit. Current flowing
15 through the conducting core is measured and the sampled current
value is converted to a composite output digital coded signal.
The composite output digital coded signal is transmitted on an
optical fiber transmission line in the form of light impulses.
The light impulses are received and the composite output digital
20 coded signal is decoded to provide an output signal represen-
tative of the value of the measured current.

The preferred embodiments of the present invention
will now be described with reference to an example thereof
as illustrated in the accompanying drawings, in which :
25   FIGURE 1 is a block schematic diagram of the converter/
transmission circuit,

FIGURE 2 is a schematic illustration of the construc-
tion of the input shunt,

FIGURE 3 is a schematic diagram of the analog portion
30 of the receiver,

FIGURE 4 is a block schematic diagram of the receiver
circuit,

FIGURE 5 is a fragmented section view of the mounting
assembly,
35   FIGURE 6 is a characteristic curve of the frequency
of response of both channels A and B,

FIGURE 7 shows the response of the system when the
shunt is replaced by a square wave voltage source,

FIGURE 8 shows a typical characteristic transfer curve of the system,

FIGURE 9 is a graph illustrating the curves which show the gain and the offset of each of the channels as a
5   function of temperature, and

FIGURES 10a and 10b, which appear with Figure 5, show display curves illustrating the functioning of the system at tests made at 1,000 amps and 50 amps.

Referring now to the drawings, and more particularly
10   to figures 1 and 2, there is shown generally at 10 the conver-
ter/transmitter which has an input shunt 11. The circuit 10 senses the current passing through the shunt, at two points P and Q, and converts and transmits signal information relating to the measured current on an optical fiber transmission line,
15   herein schematically illustrated at 12, to a remote receiver circuit, which will be described later.

As shown in figure 2, the shunt 11 is of a co-axial design comprising an inner resistive conductive tube 13 for conducting current from an input connection 14 down through
20   the tube 13 and upwards on an outer conducting tube 15 to an output connection 14'. The inner resistive tube 13 is provided with an internal chamber 16 which is free of electric and magnetic fields related to the measured current. The converter/ transmitter circuit 10 is mounted within the internal chamber
25   16.

The input connections 17 of the converter/transmitter 10 is connected to the inner resistive tube 13 at the two predetermined connecting points P and Q separated by a know distance, herein 10,50"(26;67 cm) which gives a resistance
30   value between the points calculated at 45,5$\mu\Omega$.

This type of coaxial shunt 11 can support continuously a current of 2200 amps (In) and maintain itself within an inter-
nal temperature of 125°C on a fault equal to 20 amps In during six cycles of the 60 Hz (0,1s.). This limit is imposed by the
35   semiconductors utilized.

The response time of such a shunt is given by the relation

$$TM = \frac{\delta \mu h^2}{6}$$

where h is the thickness of the resistive tube 13 in meters

μ is the permeability in H/m, and

σ is the conductivity in mho/m.

5   In the present use of such a shunt, we have

$$\mu \simeq \mu_0 = 4\pi \times 10^{-7} \text{ (monel K)}$$

$$\sigma = \frac{1}{0,603 \times 10^{-6}} \text{ mho/m}$$

10         $h = 0,012 \text{ m}$

Thus, the response time TM = 50 μS.

The approximate pass band is given by the relation ship

15
$$B = \frac{0,35}{2 \text{ Tm}} = 3500 \text{ Hz}$$

This pass band is superior to the system specification aimed and namely a frequency of 600 Hz.

As previously mentioned, measuring points P and Q
20 (see Fig. 2) on the shunt 11 are 10,50" (26,67 cm) apart which gives a resistive value of 45,5 $\mu\Omega$, or a voltage of 100 mV for 2200 amps (nominal current).

Because the electronics must operate in an ambient temperature range of between −55°C to +125°C, and because of
25 the dynamic range to be covered (.1 In to 20 In) this dictates the use of two analog/digital converters 21 and 22 operating with input signals having a difference in relationship by a factor of sixteen (16) giving two channels A and B.

Referring to figure 1, the converter/transmitter 10
30 comprises a first input amplifier 20 which is utilized to permit simultaneous adjustment of both channels A and B. In the present transmitter design the amplifier 20 has a gain of 3,535 which can permit the measurement and the transmission of a current of 44 kA RMS (20 In) on the first channel A and current of
35 2,75 kA RMS on the second channel B.

Converters 21 and 22 are each fed by a Sample and Hold circuit 23 and 24, respectively, with the sampling circuit 24 being fed by a second amplifier 25 having an amplification factor of x 16. The Sample and Hold circuit 23 is fed by the output

of the first amplifier 20. Also, the Sample and Hold circuits
23 and 24 are each controlled by a controller circuit 26
which provides trigger pulses every 40 µS to the circuits 23
and 24, whereby to obtain a sample of the current value using
5   channels A and B. The controller also feeds control pulses
to the converters 21 and 22 and to a shift register 27 which
makes a parallel to series conversion. The results of the
conversion at the output of each of the converters 21 and 22
is a 12 bit word and these words are combined (24 bits) into
10   a composite output digital coded signal of 31 bits in the
register 27. The register 27 adds trigger and control bits
in order to eliminate long chains of "0" and "1". There cannot
be a series of eight consecutive "0" except between two words
(between 31 bit words). The controller 26 can also be adapted
15   to receive a remote control signal to obtain a synchronized
sampling when two or more systems are used to measure other
currents such as on each line of a 3-phase power line.

The composite output digital coded signal at the
output 28 feeds a light -emitting diode 29 of the type Texas
20   Instrument TIXL 472, which transmits light impulses in the
fiber optical transmission line 12. Other forms of light
transmission devices, such as lasers, may be utilized for this
purpose. The transmission line 12 is herein comprised of a
bundle of six optical fibers. However, the line could consist
25   of a single fiver or other size of bundle. The controller
circuit 26 controls the sampling sequence and the transmission
sequence. In specific applications, the sampling is obtained,
converted and transmitted every 40 µS. The transmission rate
on the optical fiber transmission line is 1 Mbits/second.
30   The calculated maximum error in the entire converter/
transmitter electronic circuit 10 is less than 0,6% of the
maximum level value for both channels A and B and this includes
all of the errors (i.e., variation of the offset of the gain)
and within the temperature range of between -55°C to +125°C.
35   In practical use, the accuracy of the converter/transmitter
is better than 0,6%. A gain resistor (not shown) in the
amplifier 20, of a type R-2R, permits a fine adjustment of the
gain of that amplifier. This permits the correction of errors

in the construction of the shunt. The second amplifier 25 has
a fixed gain of x 16. The resistors in both amplifiers are
of the thin film type which have a very high stability to
temperature change.

5   Referring now to figures 3 and 4, there is shown the
construction of a receiver circuit. Figure 3 is a schematic
of the diode and preamplifier input illustrated by block 30 in
figure 4, and figure 4 is a block diagram of the entire receiver
circuit generally indicated by reference numeral 40.

10   Referring now to figure 3, the optical detector input
circuit 30 consists of an input receiver 31 using a photo-
electric avalanche type Texas Instrument TIXL 452. The band
pass (500 MHz) of the diode in circuit 31 is practically
limited to 50 MHz by the preamplifier included within the
15   receiver. Such an input circuit is adequate for the present
receiver. The amplifier 33 is used to increase the amplitude
of the signal at the output 34 of the receiver 31, which
receiver is fed by the composite output digital coded signal
received on its optical fiber input connection 35. The ampli-
20   fier 33 permits the adjustment of the mean value of this
signal. The amplifier 33 feeds two inverters 36 and 37 which
condition the signal to obtain standard TTL levels at the
output 38.

          Referring now to figure 4, the output 38 is connected
25   to two detector circuits 41 and 42 to detect the transition
and the code of the digital signal, i.e., (1) or (0). The
receiver 40 consists of decoding circuit means for decoding
and reconstituting the coded signal at 38 to a usable form
to determine the value of the sampled current at the input of
30   the transmitting circuit 10. The decoder receiver 40 utilizes
a 20 MHz oscillator in the clock circuit 43. This oscillator
gives a 1 MHz clock using a divide by 20 counter (not shown).
Thus, the 1 MHz clock has a plurality of outputs all in phase.
The transition detector 41 has an output 41' connected to the
35   clock 43 to synchronize and reset the 1 MHz clock in accordance
with the received signal and within an error signal smaller
than the duration time of a single bit divided by 20. The clock
43 has an output connection 43' which feeds the detector 42
whereby to sample the signal every 0,5 μS after the instant in

which a transition could take place. Thus, sampling occurs in the middle of a bit duration.

A divide by 8 counter 44 is connected to an output 45 of the detector 42 and identifies the separation (at least eight consecutive "0") between the 31 bit composite signals to determine the start of a word to be decoded. The counter 44 has an output 46 feeding control signals to a divide by 31 counter 47. The clock 43 synchronizes counter 44 by feeding clock pulses on its input 46'. The divide by 31 counter 47 is also synchronized to the clock 43 through input connection 47' and further receives the output signal of output 41' of the detector 41 at its input 48. The counter 47 also detects the end of the 31 bit coded signal. The output 49 of the divide by 31 counter 47 feeds the memory circuit 50 to provide the word identification signal thereto whereby it can latch the two 12 bit words representative of the sampled current values at channels A and B of the transmitter 10.

The output 51 of the detector 42 also feeds the input of a shift register circuit 52 which does the series to parallel conversion and is clocked by its input 52'. The output 53 of the shift register 52 transfers the 24 bit information signal (two 12 bit words) to the memory circuit 50. The transfer of the information from the register 52 is done by the memory circuit 50 which is fed with identification signals by the divide by 31 counter 47 after 31 bits have been received. Control bits are also provided to detect errors and to give a "busy" and "data available" signal for use of the output 54.

The memory 50 is provided with two output circuit means one giving a direct digital signal at output 54 which may provide a display of the 24 bits by electroluminescent diodes (not shown). Another output circuit means feeds a digital/ analog converter circuit 55 which is a 16 bit converter which permits it to convert an input signal fed on its input 56, and consisting of a 16 bit signal, and to provide an analog output 57 as a voltage with a scale of $\pm$ 5 volts. A channel-determining circuit 58 is fed by outputs 59 of the memory 50 and it automatically samples the two 12 bit signals to determine if the channel B is saturated thus permitting the circuit 58 to decide

which of the two channels is more accurate. Channel B is
saturated if the 12 bits are all at "O" (zéro) at the transi-
tion period of scale A or all at "l" (one). A timing circuit
(not shown) permits a return to scale B, a certain period of
5   time after channel B has desaturated, to prevent shifting of
the scales at the zero transition of the signal, particularly
when the signal is strong. A manual adjustment element (not
shown) can also be provided to impose a desired one of the two
scales on the converter 55. The output of the receiver thus
10 permits monitoring of the current on the high voltage line for
corrective action.

        Referring now to figure 5, there is shown a preferred
construction of a mounting assembly. As herein shown, the shunt
11 is secured atop an insulating column 60 on top of a generator
15 housing 61. A generator 62 is housed within the housing 61 and
driven by an insulated drive shaft 63 which extends through
a bore 64 in the column 60. The drive shaft 63 is driven by a
motor 65 located in a mounting base 66 of the assembly. The
bore 64 has a pressurized gas therein which prevents the ingres-
20 s of humidity. The motor/generator arrangement (65,62) consti-
tutes a 400 Hz power supply. Two 400 Hz transformer-rectifier-
regulator assemblies feed the ± 15 volts and the + 5 volt power
for the operation of the transmitter 10 located in the shunt
11.

25   A prototype has been built and in a first period tested
with a voltage source simulating the shunt. Figure 6 illustrates
the pass bands of both channels A and B with a 100 mV input and
figure 7 illustrates a response curve on a CRT display scale.
A series of curves have been traced for each channel in relation
30 to temperature. These curves have been obtained on a point to
point basis by feeding a series of constant voltage values at
the inputs of the transmitter 10. Figure 8 illustrates the
response curve obtained by this method.

        Referring to figure 9, there is shown a compilation of
35 all the curves which illustrates the gain and the offset of
each of the channels at various temperatures. These gains and
offsets were obtained by the square means method. Figure 9
illustrates clearly the improved stability of the gain and the
offset for each of the input levels. The curves illustrate a

difference of the gain of 0,3% between the two input levels.
The difference of the offset was due to a bad adjustment of
the transmitter. It is also pointed out that these curves
stop at 80°C. After the system was stabilized at 80°C during
5   a period of one half hour, the temperature was raised to
125°C during two minutes. This two minute period is sufficient
for the test (not to damage the circuit components) and should
exceed a practical situation where a fault would occur at maxi-
mum voltage during a period of 0,1 second. No damage was made
10   to any of the components of the system. After returning to a
temperature of 70°C the calibration of the system was verified
and all was in order.

     High current tests were also made utilizing a 60Hz
transformer which fed a 2000 amp current through the shunt.
15   Il was verified that the current did not affect the electronic
circuit located in the shunt by short-circuiting the transmitter input
inside the shunt. Figures 10a and 10b illustrate measurements
taken at high current tests effected between 0 and 2000 amps.
Figure 10a shows the output with a 1000 amp current input,
20   while figure 10b shows the output with a 50 amp current input.
The apparatus proved operational at these high current values.

     It is within the ambit of the present invention to
cover any obvious modifications of the example of the prefer-
red embodiment illustrated and described herein. With the
25   method of the present invention, it is conceivable to use
the system on high voltage transmission lines of 735 kV. It is
also foreseen that new amplifiers with programmable gains could
be used and would permit to increase the number of scales to use
an analog/digital converter close to its maximum input value.
30   The principal object is to have a very small error on the
sensed value of small currents. On the other hand, the phase
error is minimized by obtaining many samples at small increments
of time. It is apparent that the sampling could be effected,
at random, from a command circuit located on the ground. Also,
35   measurement could be synchronously made on the three phases
of the same transmission line.

     Further, it is conceived that the shunt could be cons-
tructed as a non-coaxial shunt with the outer conducting tube
15 secured behind the inner conductive tube 13, that is to say

in series. The electronics of circuit 10 could be housed
within the tube 15.

CLAIMS

1. A system for sensing and measuring current on a
high voltage transmission line characterized in that it
comprises an input shunt element (11) connected to said trans-
mission line for sensing a current flowing therethrough, a
transmitter circuit for transmitting a signal representative
of said current passing through said shunt element, said
transmitter having converter means for producing a composite
output digital coded signal representative of the value of
said measured current, a light transmitting output means (28)
for transmission of said coded signal on an optical fiber
transmission line (12) to a receiver circuit (31) having decoding
circuit means for decoding and reconstituting said coded signal
to a usable form to determine said value of said measured
current, said shunt element having a resistive conducting core
(13) with an internal chamber (16), said transmitter circuit
being contained within said internal chamber to shield its
circuitry from electric and magnetic fields produced by said
current flowing through said conducting core around said
transmitter circuit.

2. A system as claimed in claim 1, characterized in
that said light transmitting output means is a light emitting
device coupled to optical fibers for transmitting light
impulses in said fibers representative of said composite output
digital coded signal.

3. A system as claimed in claims 1 or 2, characterized
in that said input shunt has two connecting points (P,Q) for
passing said current to be measured, said transmitter circuit
having two channels each having an analog to digital converter
(21,22), a first amplifier (20) for adjusting simultaneously
both channel levels and feeding a first input signal to one of
said converters, a second amplifier (25) connected to an output
of said first amplifier to provide an amplified input signal to
a second one of said converters.

4. A system as claimed in claim 3, characterized in
that said digital converters each feed a 12 bit signal repre-

sentative of their input signal to a shift register circuit
(27) to effect a parallel to series conversion to provide said
composite output digital coded signal, and a control circuit
(26) to provide trigger and control pulses to said shift
register circuit to provide identification and trigger bits
in said composite output digital coded signal and to effect
sampling of said current to be measured by said transmitter
circuit and at predetermined time limits.

5. A system as claimed in any preceding claim,
characterized in that said transmission line has one or more
optical fibers fed by said light emitting device which is a
light emitting diode, said transmission being of the serial
asynchronous type carrying said coded signal which is a multi-
bit word separated by a predetermined series of known bits.

6. A system as claimed in any claims 1 to 4, characte-
rized in that said transmission line has one or more optical
fibers fed by said light emitting device which is a light
emitting diode, said transmission being of the serial syn-
chronous type carrying said coded signal which is a multi-
bit word separated by a predetermined series of known bits.

7. A system as claimed in claim 4 characterized in
that said receiver circuit comprises a photoelectric input
diode for receiving said light impulses, a preamplifier to
amplify output signals of said input diode, said decoding
circuit means reconstituting said coded signal into usable
signals representative of said two 12 bits signals.

8. A system as claimed in claim 7, characterized in
that said decoder circuit comprises an oscillator clock
circuit (43) operating at a frequency of 20 MHz, a transition
detector (41) to synchronize said oscillator clock circuit
relative to the start of a received composite signal, said
clock circuit enabling sampling said received composite signal
in a bit detector (42) in the middle of a bit duration to re-
produce said received composite signal, a divide by 31 bit
counter (47) enabled by said transition detector to instruct
a memory circuit (50) to transfer said two 12 bit coded word
signals in said composite signal from a series/parallel

converter circuit fed by said bit detector, said memory circuit
receiving said two 12 bit coded word signals for processing,
said memory circuit having output means to display said recei-
ved signal.

5   9. A system as claimed in claim 8, characterized in
that said output means is a direct digital output 24 bit
signal to permit display and use of said two 12 bit coded
word signals.

10   10. A system as claimed in claim 9, characterized in
that said output means comprises a digital/analog converter
circuit (55) fed by a level selector circuit (58) which
receives said two 12 bit coded word signals from said memory
circuit and automatically selects a preferred one of said two
15 signals, said digital/analog converter circuit having an output
which reconstitutessaid selected one of said two signals as an
output voltage display on a ± 5 volt scale.

         11. A system as claimed in any preceding claim,
characterized in that said shunt is a coaxial cylindrical shunt
20 having an inner conductive tube (13) and a coaxial outer
conductive tube (15), said chamber (16) being defined inter-
nally of said inner conductive tube, said inner conductive
tube providing voltage signals proportional to said current
flowing therethrough.

25   12. A system as claimed in claim 11, characterized in
that said coaxial shunt is secured on an insulating column
(60) and having a driven generator (62) interposed therebetween
to provide the required supply voltages to said transmitter,
said generator being driven by an insulated drive shaft (63)
30 extending in a bore through said column, and a motor (65) at
a base of said column for driving said shaft.

         13. A method of sensing and measuring current in a
high voltage transmission line characterized in that it comprises
the steps of
35   i) securing a shunt element having a resistive
conducting core to said high voltage transmission line, said
shunt element having an internal chamber,
         ii) locating a transmitter circuit within said internal

chamber to shield its circuitry from electric and magnetic
fields produced by current flowing through said conducting
core around said transmitter circuit,

iii) measuring current flowing through said conduc-
ting core,

iv) converting said sampled current value to a
composite output digital coded signal,

v) transmitting said composite output digital coded
signal on an optical fiber transmission line in the form
of light impulses, and

vi) receiving said light impulses and decoding said
composite output digital coded signal to provide an output
signal representative of the value of said measured current.

14. A method as claimed in claim 13, characterized
in that said sampling is effected by using two or more channels
to obtain two or more signal levels, adjusting simultaneously
said two or more signal levels by means of a first amplifier
to provide a first input signal to constitute a first coded
12 bit word signal.

15. A method as claimed in claim 14 characterized in
that there is further provided the step of multiplying said
measured current through a second amplifier having a known
multiplication factor to provide a second coded 12 bit word
signal whereby said composite output digital coded signal
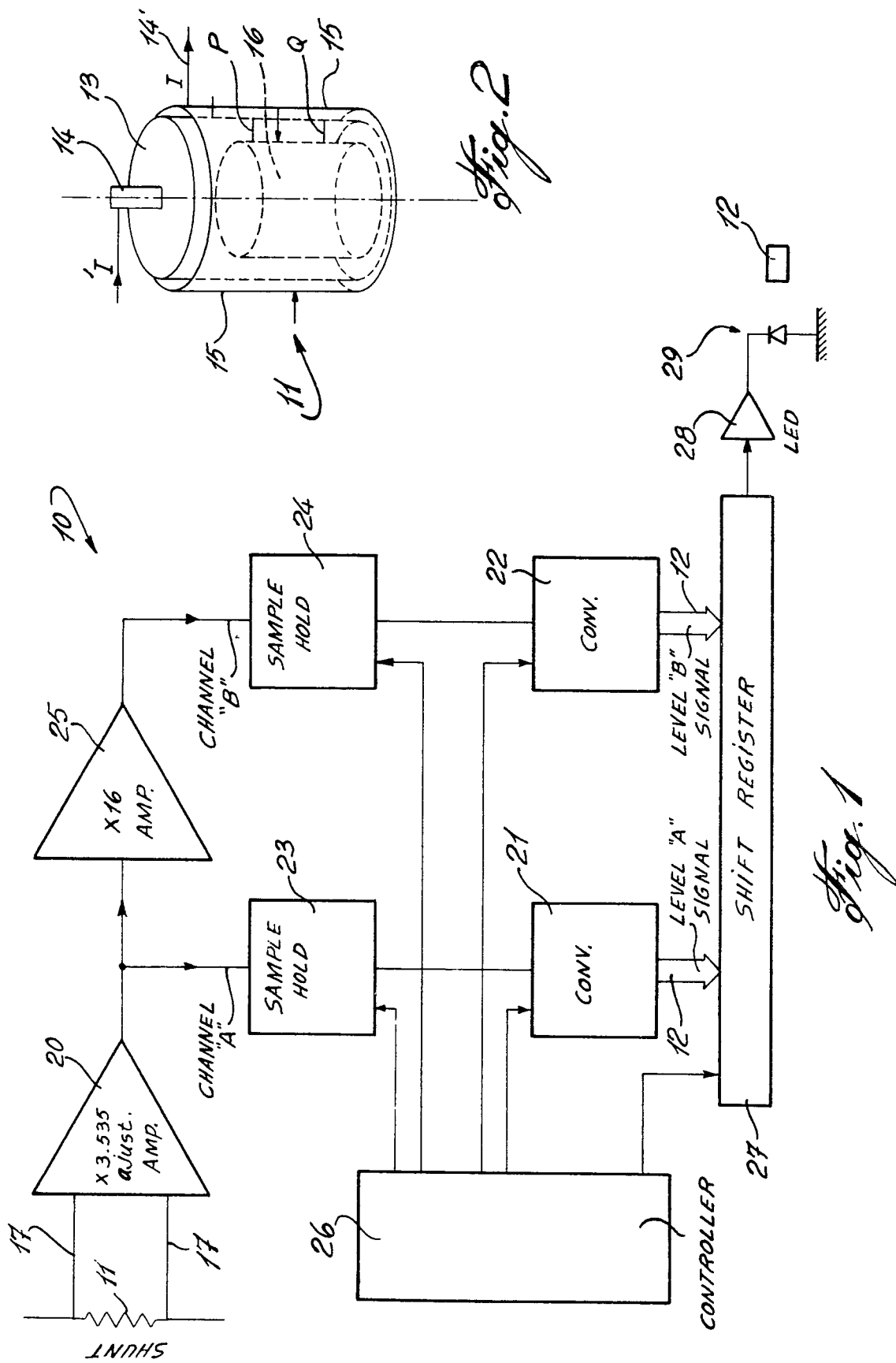is composed of two 12 bit word signals.

16. A method as claimed in claim 15, characterized in
that there is further provided the step of providing adjustment
means to obtain a desired sampling time of said current flowing
through said conducting core, and identifying the location of
said two 12 bit word signals in said composite output digital
coded signal.

17. A method as claimed in claim 15, characterized in
that said step (vi) comprises

a) detecting the start and end of said composite
output digital coded signal,

b) transferring said two 12 bit word signals to a
memory circuit for processing to provide an output signal
reconstituting the value of said sampled current, and

c) selecting a preferred one of said two 12 bit
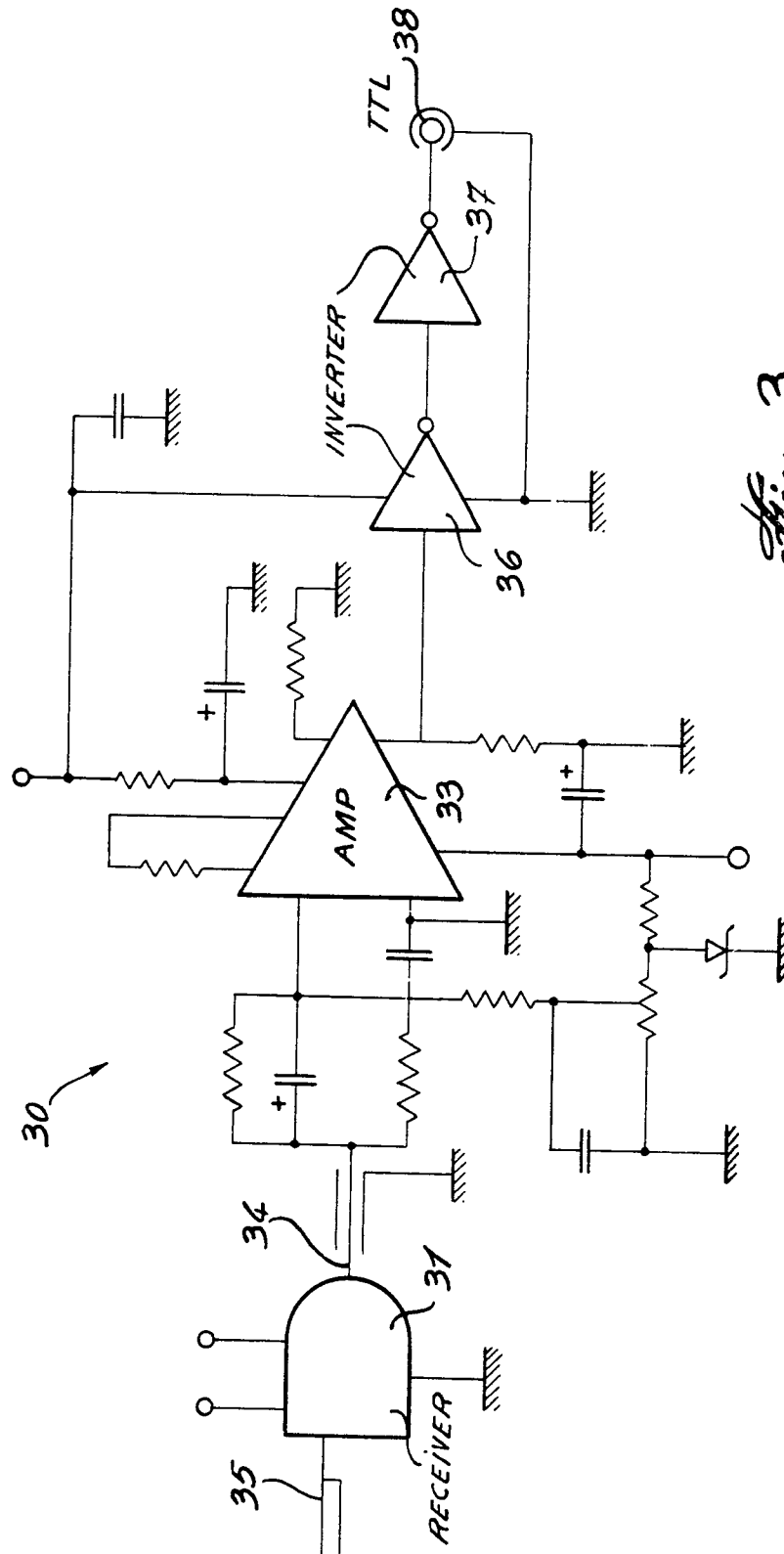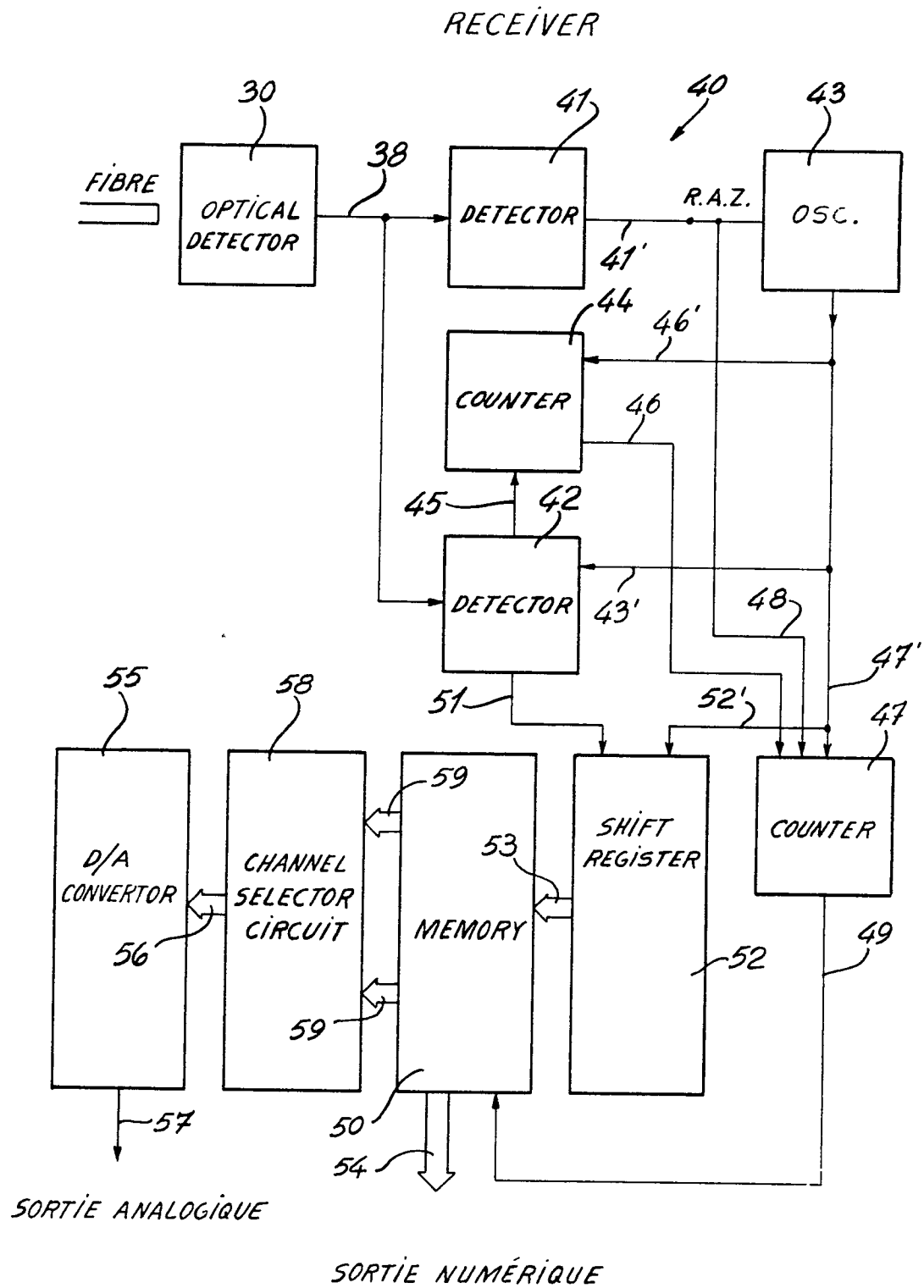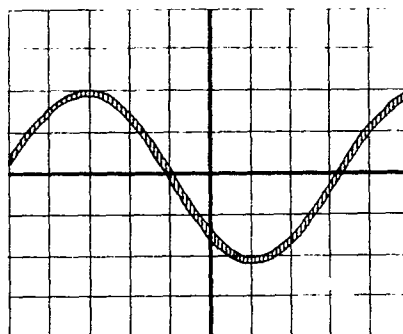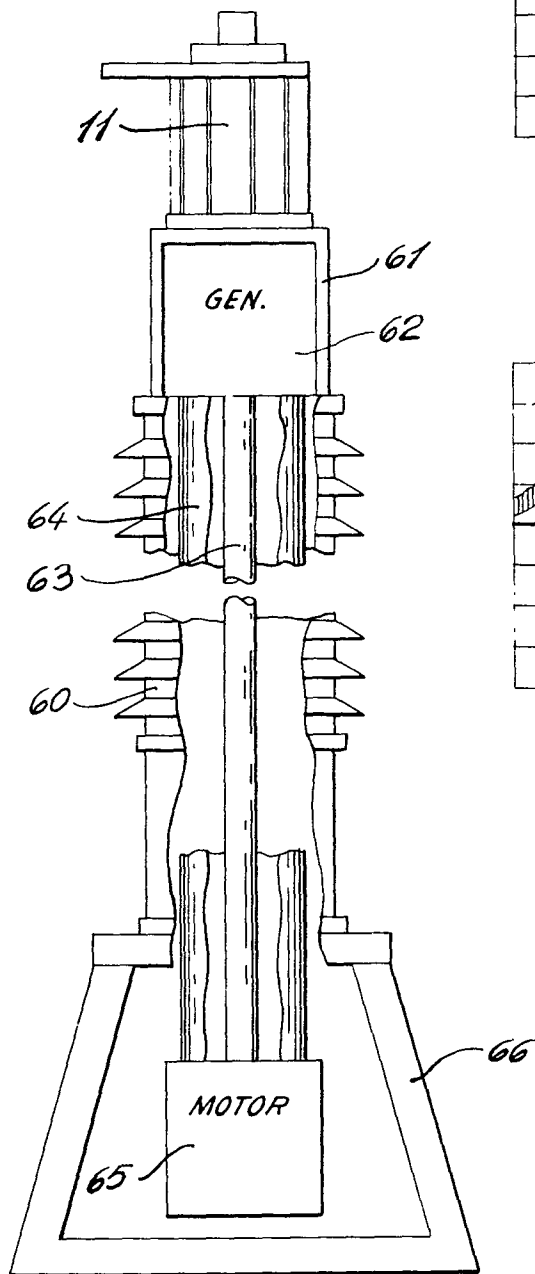
5 word signals.

Fig. 2

14' I P 16 Q 15
13 14
I'
15 15 11

Fig. 1

10

SHUNT
11
17 17

20 X 3.535 Adjust. Amp.

25 X16 Amp.

CHANNEL "A"
CHANNEL "B"

23 SAMPLE HOLD
24 SAMPLE HOLD

26

21 CONV.
22 CONV.

LEVEL "A" SIGNAL
LEVEL "B" SIGNAL

12 12
12

SHIFT REGISTER

27

CONTROLLER

28 29

LED

12

Fig. 3

RECEIVER

FIBRE

OPTICAL DETECTOR — 30

38

DETECTOR — 41

41'

40

R.A.Z.

OSC. — 43

COUNTER — 44

46'

46

45

42

DETECTOR

43'

48

51

52'

47'

D/A CONVERTOR — 55

CHANNEL SELECTOR CIRCUIT — 58

59

MEMORY — 53

SHIFT REGISTER

COUNTER — 47

56

59

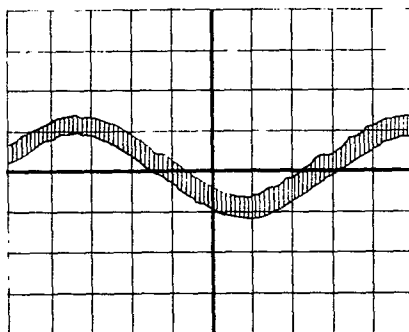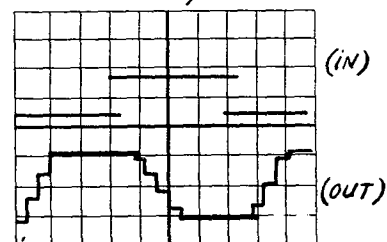52

49

57

50

54

SORTIE ANALOGIQUE

SORTIE NUMÉRIQUE

Fig.4

Fig. 10A

I = 1000A
VERTICAL 50m/div.
HORIZONTAL 2ms/div.

I = 50A
VERTICAL 5mV/div.
HORIZONTAL 2ms/div.

Fig. 10B

2V - 100μs

(IN)

(OUT)

RESPONSE OF SYSTEM
TOP - (IN)
BOTTOM - (OUT)

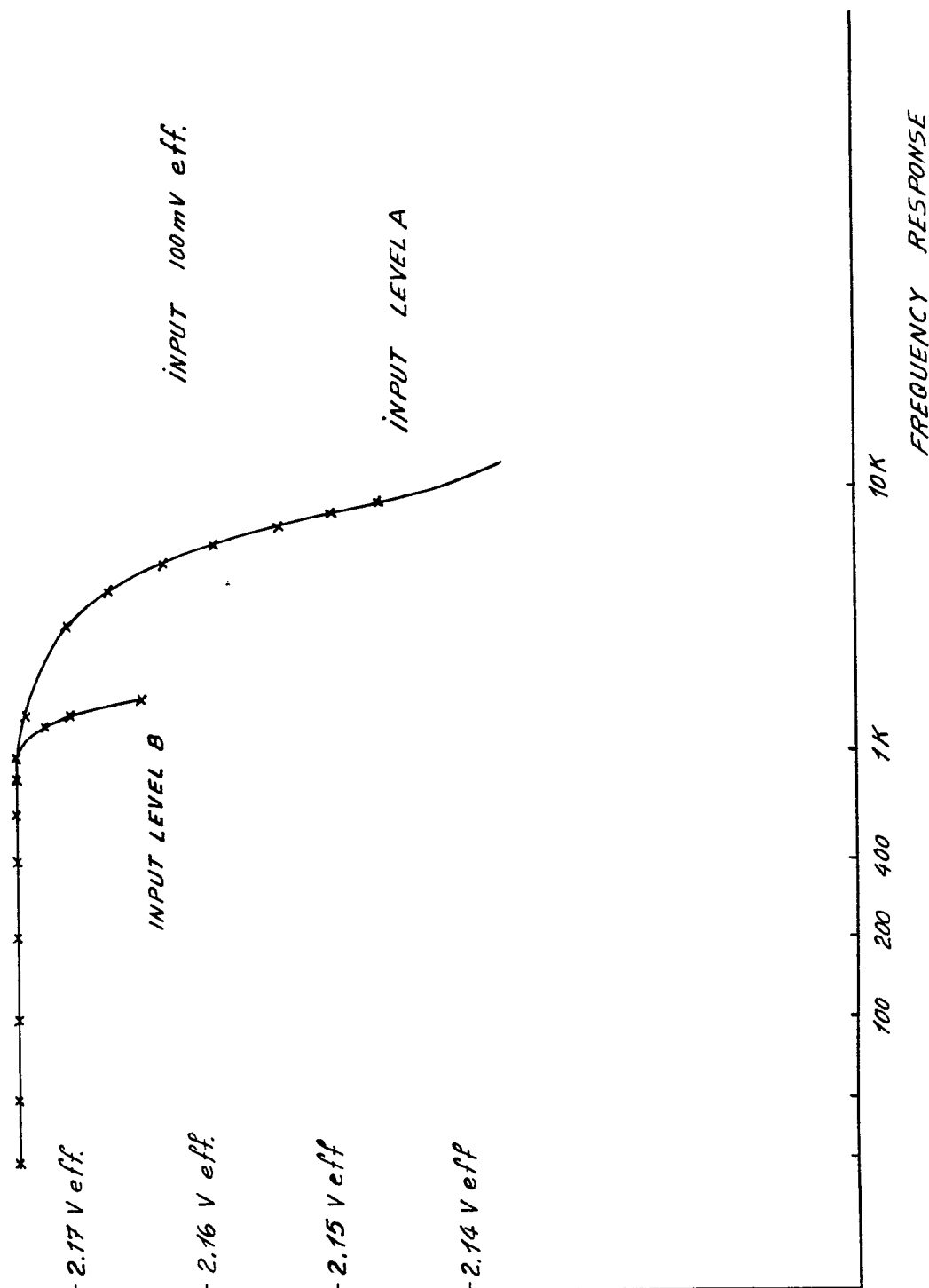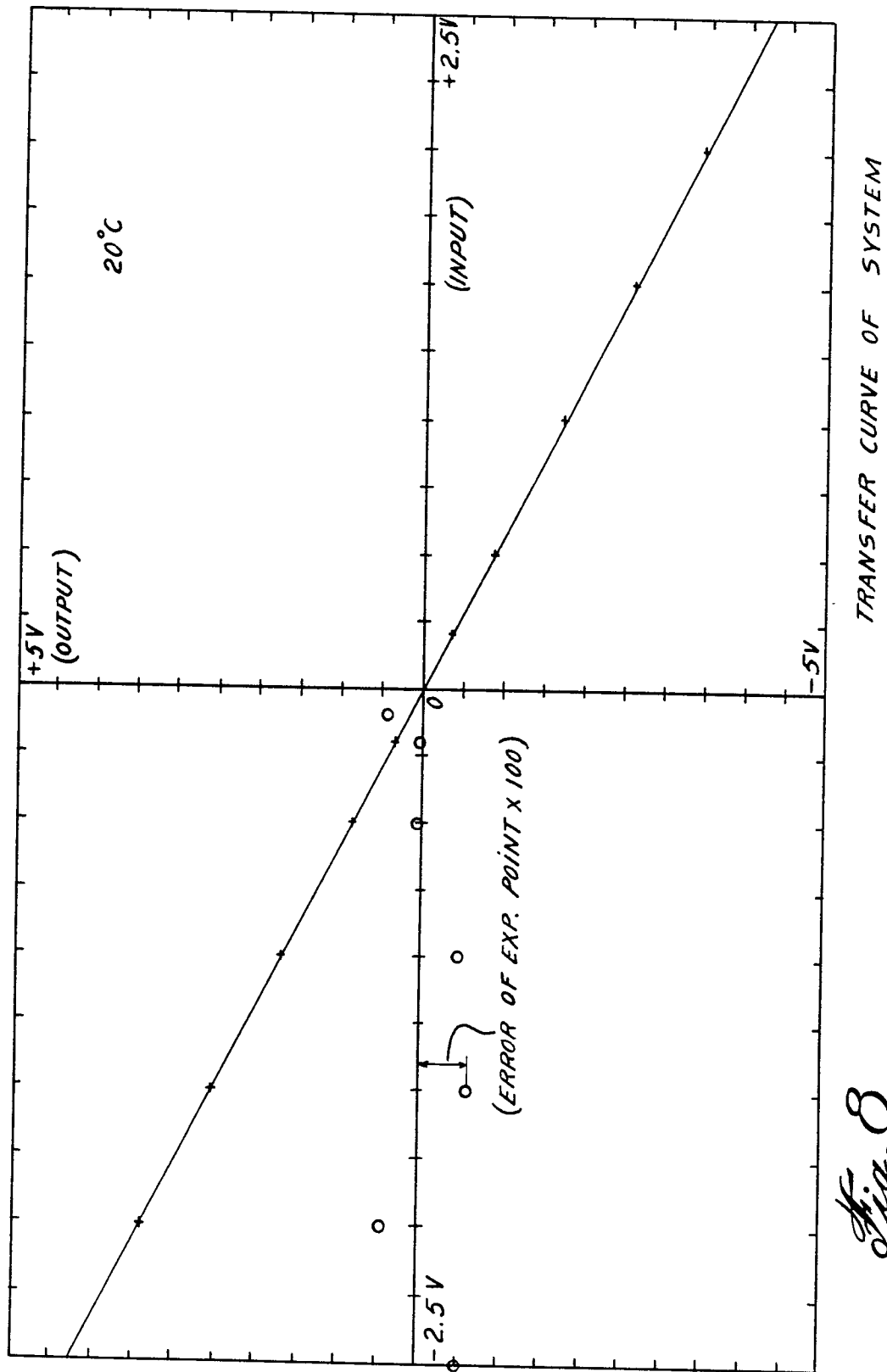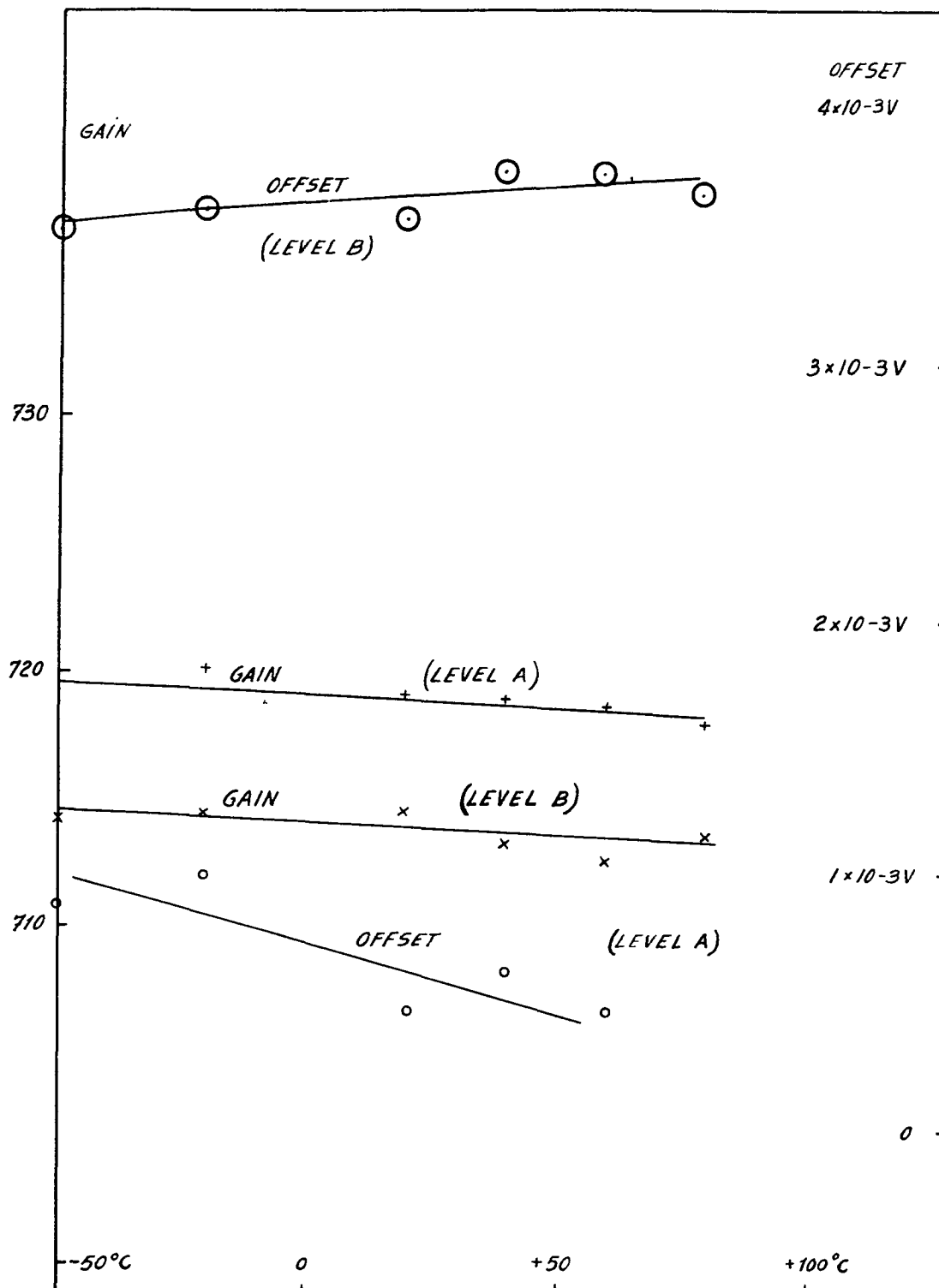*Fig. 7*

Fig. 5

Fig. 6

INPUT 100mV eff.

INPUT LEVEL A

INPUT LEVEL B

2.17 V eff.

2.16 V eff.

2.15 V eff

2.14 V eff

100   200   400   1K   10K   FREQUENCY RESPONSE

20°C

+5V
(OUTPUT)

+2.5V
(INPUT)

-5V

0

-2.5V

(ERROR OF EXP. POINT × 100)

TRANSFER CURVE OF SYSTEM

Fig. 8

GAIN AND OFFSET OF THE TWO CHANNELS
AS A FUNCTION OF TEMPERATURE

Fig. 9

European Patent
Office

EUROPEAN SEARCH REPORT

0026930

~~Application Number~~

EP 80 10 6009

	DOCUMENTS CONSIDERED TO BE RELEVANT		CLASSIFICATION OF THE APPLICATION (Int. Cl.³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	DE - A - 1 939 510 (SIEMENS AG) * Page 1, paragraphs 1,2; page 3, paragraph 3; page 5, last two paragraphs; pages 6-8; paragraph 1; figure 1 * --	1,2,5-7,13
	DE - B - 1 264 606 (SIEMENS AG) * Column 2, lines 46-52; column 3, lines 1-10; column 5, lines 61-68; column 6, lines 1-55; figure 1 * --	1,2,7,13
	DE - B - 1 303 767 (SIEMENS AG) * Column 1, lines 1-28; claim; column 4, lines 4-40; figure * --	1
	IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS, vol. PAS-94, no. 6, November/December 1975, pages 2124-2130 New York, U.S.A. J.S. SUBJAK JR.: "An EHV current transducer with feedback-controlled encoding" * Page 2125, left-hand column, second half (Block Diagram); figure 1 * ----	1,2

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

G 01 R 15/07
G 08 C 23/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

G 01 R 15/07
G 08 C 23/00
        19/28
H 04 B 9/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	09-01-1981	KUSCHBERT